AN ABSTRACT OF THE THESIS OF

Mitchell Leary for the degree of Master of Science in Environmental Health Management presented on November 21, 1997. Title: Are Graduating B.S. Engineering Students With Environmental Safety and Health (ES&H) Education More Likely To Gain Employment Compared With Those Who Do Not Have ES&H Education?

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Abstract Approved: _

Annette M. Rossignol

The Accreditation Board for Engineering Technology (ABET) requires that safety and health be integrated into an engineering curriculum in order to be accredited. These criteria for safety and health requirements, however, are not clearly defined. The National Institute for Occupational Safety and Health (NIOSH) has initiated Project SHAPE (Safety and Health Awareness for Preventative Engineering) instructional topics and curriculum development for engineering programs for the greater than 300 ABET accredited engineering schools.

The present study was designed to evaluate how important safety and health (addressed as Environmental Safety and Health) knowledge/education are to an employer when seeking graduating Bachelor of Science Engineering students at Oregon State University (OSU). The study also seeks to find out what magnitude of ES&H instruction/knowledge is desired by prospective

employers. And finally, the type or level of knowledge/education employers are seeking in their prospective OSU engineering employee.

A questionnaire was developed and targeted at companies who recruited graduating Bachelor of Science Engineering students at OSU for employment during the 1993/1994 and 1994/1995 academic years. A roster of recruiters and the companies they represented generated a population of 110 recruiters from records kept in the Oregon State University Career Placement Office. Each recruiter was requested to complete a four page questionnaire. Participants were requested to rank qualifications for employment when seeking prospective engineering employees; how important ES&H were when considering a candidate; what kind and level of ES&H knowledge/education was preferred; and if a graduating B.S. Engineering student with ES&H knowledge/education was more likely to gain employment with their firm. A total of 72 surveys were returned, for an overall response rate of 65.5%.

The results indicated that recruiters seeking graduating B.S. engineering students at OSU found ES&H knowledge/education 'Not Too' or 'Not At All' important when considering them for employment. However, the majority of those recruiters that indicated ES&H was an important qualification when considering an engineering candidate for employment, indicated the source of ES&H knowledge/education was through integration into the engineering curriculum.

Are Graduating B.S. Engineering Students With Environmental Safety and Health (ES&H) Education More Likely to Gain Employment Compared With Those Who Do Not Have ES&H Education?

by

Mitchell Leary

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Mitchell Leary, Author

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DEDICATION

I want to dedicate this thesis to my loving wife, Shellie, and wonderful children, Bryan, Amy, and Rob, and to the strength we all received from our Lord Jesus Christ.

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Likely to Gain Employment Compared With Those Who Do Not Have
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INTRODUCTION

Safety and health are a guiding criterion for accrediting Schools of Engineering in the United States by the Accreditation Board for Engineering Technology (hereafter known as ABET). The criteria for these safety and health standards have undefined outcomes. Therefore, the depth and breadth of safety and health education need to be clearly stated for standard outcomes for all engineering schools receiving accreditation from ABET.

NIOSH (National Institute of Occupational Safety and Health) initiated a series of workshops to recommend methods for improving engineering practices, education, and research in the OS&H field (Talty, 1986). One of the results of the workshops was the initiation of Project SHAPE (Safety & Health Awareness for Preventative Engineering). NIOSH initiated a series of curriculum development projects emphasizing that the engineering community is in a position to make major contributions to the prevention of workplace injuries and illnesses. However, the engineering community needs to partner with the safety community to converge thinking on how safety and health are to be best integrated into the curriculum. At the same time, industry needs to partner with these two communities and identify how these integrations will best benefit the curriculum, industry and society as a whole.

The present study was designed to evaluate how important safety and health (addressed as Environmental Safety and Health) knowledge and education are to an employer when seeking to hire graduating Bachelor of Science engineering students. For the purpose of this study, Environmental Safety and Health will be defined as the area of science and technology that anticipates, recognizes and controls environmental factors and personal stresses arising in or from the workplace. These conditions may result in injury, impaired health, significant discomfort, or lowered efficiency among workers and members of communities. The study sought to assess what magnitude of safety and health knowledge is desired by a prospective employer. The study was designed to evaluate whether knowledge of safety and health gave BS engineering students an advantage when seeking employment. And finally, the study sought to find out the level of ES&H instruction and knowledge employers are seeking in their prospective engineering employee.

LITERATURE REVIEW

In today's employment climate, graduating Bachelor of Science Engineering students are facing greater challenges in the workplace than ever before in history. Studies have been done to evaluate the engineering curriculum and coursework for the engineer's appropriate preparation for the workplace. Besides the pure engineering responsibilities, costs, legal and ethical implications, liability, and safety are becoming standard job duties for engineers (Fleischman, 1988; Kavianian, 1993). Safety concerns for employees and society from design inception to performance and repair, to dismantle and disposal, are being given to engineers (Roland and Moriarty, 1990). Major industrial accidents, such as Bhopal, the Exxon *Valdez* oil spill, Chernobyl, Three Mile Island, and the Mexico City explosion, illustrate trends and events that are pushing industry and society toward a much greater awareness of health and safety issues (Kauffman, 1987; Lemkowitz, 1992; Webb, 1994).

Project SHAPE

United States society, as a whole, desires greater technological advances. At the same time, it requires or demands the elimination or reduction of the safety and health risks associated with these advances (Webb, 1994). These desires are directly related to engineering practices. In 1979, NIOSH (The

Table 1

Suggested OS&H Instructional Topics (Talty, 1986)

1. Air Contaminants	11. Industrial Toxicology	21. OS&H Literature
2. Control Technology	12. Industrial Ventilation	22. Personal Protective Equipment
3. Electrical Safety	13. Loss Control	23. Product Liability
4. Emission Control	14. Materials Handling	24. Radiation Control
5. Engineering Control Systems	15. Mechanical Guarding	25. Respiratory Protection Equipment
6. Epidemiology	16. Monitoring	26. System Safety
7. Ergonomics/Human Factors	17. Noise Control	27. Vibration Control
8. Facility Layout	18. Occupational Diseases	28. Waste Disposal
9. Fire Protection	19. Occupational Injuries	29. Work Practices
10. Illumination/Lighting	20. OS&H Codes and Standards	

National Institute for Occupational Safety and Health) sponsored an Engineering Control Technology Workshop which concluded that there was a critical need to include occupational safety and health (OS&H) in the education of engineers. A second workshop was held in 1981 and included presentations by industrial representatives who emphasized the need to include health and safety criteria in the engineering design process. During the second workshop, a recommendation was made to prepare a workshop report for the purpose of identifying ways and methods of including OS&H into the engineering curriculum. A panel of technical experts from industry, government, and academia was selected to prepare the report. This report and the recommendations were presented in 1983 at the third workshop. This session included discussion of legal responsibilities, accreditation of engineering programs, and registration of engineers, and concluded with a review of the report of the 1982 workshop. A listing of the workshop reports and a summary report have been published and are available through NIOSH. One of the results of the workshops was Project SHAPE (Safety and Health Awareness for Preventative Engineering). SHAPE was developed by NIOSH to help meet the engineering concerns of the rising costs related to death, injuries and illnesses on the job. "NIOSH concluded that the talent and ability of managers and engineers should be applied to the solutions through education programs concerning safety and health" (Talty and Walters, 1987). The focus of this project has been to integrate safety and health into the engineering curriculum at the approximately 300 schools that graduated engineers with a baccalaureate degree in 1985 (Talty and Walters 1987). The instructional topics (Table 1) were developed by NIOSH based on the findings of the curriculum development projects at Purdue University, Ohio State University, Georgia Tech, and Tufts University. They reflect the need for the curricula to address the major technical elements of occupational safety and health (Talty, 1986). In each case, faculty developed programs of instruction in OS&H for upper-level (senior and graduate) engineering students. If these graduates had received a basic knowledge of OS&H, the implications for a safer work environment as a result of their knowledge and influence has far reaching implications. The development of a full understanding of safety and health must become an integral part of the education of every engineer (Talty,1985). The Accreditation Board for Engineering Technology (hereafter known as ABET) adopted curricular objectives calling for an emphasis of health and safety in all accredited engineering education programs.

ABET

ABET was created by engineering societies to administer a program for accrediting engineering academic programs. In recent years, the board has sought to integrate safety and health into the engineering curriculum as one of its accrediting criteria. In their 1985 annual report, ABET stressed the need for significant increased emphasis on safety and health, both occupational and public, in the education of engineering students. Among the purposes of ABET, as delineated in its constitution, the following citation relates to curricular objectives for the Accreditation of an Engineering School (IV.C.2): "...(4) an understanding of the engineer's responsibility to protect both occupational and public health and safety" (Criteria for Accrediting Programs in Engineering in the United States, for Programs Evaluated during the 1997-1998 Accreditation Cycle). ABET currently is revising it's standard for accrediting criteria in the area of safety and health. The new standard is entitled *Engineering Criteria 2000*. For the *Engineering Criteria 2000*, which will be a three-year phased accreditation cycle, Criterion 3 states, "The program outcomes and assessment in which engineering programs must demonstrate that their graduates have, ... (f) An understanding of professional and ethical responsibility; and, (h) the broad education necessary to understand the impact of engineering solutions in a global and societal context" (ABET Criteria 2000). In Criterion 4, the Professional Component of Criteria 2000, "Students must be prepared for engineering practice through the curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier coursework and engineering standards and realistic constraints that include the following considerations: Economic; Environmental; Sustainability; Manufactureabilty; Ethical; Health and Safety; Social; and Political" (ABET Criteria 2000). Under both criteria, engineering schools are required to prepare students to practice engineering principles with health and safety as a guiding component.

Engineering Criteria

These guiding standards or criteria are conceptually sound. Unfortunately, however, the reality is that most engineering instructors have had little, if any, formal safety training or instruction themselves (Main and Ward, 1992; Flieschman, 1988). In 1986, Talty wrote "...There are a limited number of health and safety practitioners working in the United States, especially those who are practicing engineers with formal education in the occupational safety and health field. Awareness and change with respect to safety and health in engineering have been growing in the past eleven years. With NIOSH instructional topics and curriculum guidelines, and the ABET accreditation criteria, schools of engineering have made some strides toward integrating safety and health into the undergraduate engineering curriculum (Farwell, 1995). However, curriculum and instruction of OS&H are still undefined. The ABET *Engineering Criteria 2000* document , which reads, "Students must be prepared for engineering practice that includes most of the following considerations: Economic; Environmental; Sustainability; Manufacturability; Ethical; Health and Safety; Social; and Political" (ABET *Engineering Criteria 2000*), does not give direct or defined requirements for these considerations. Many colleges of engineering have responded negatively in the past to ABET's recommendations and requirements due, in part, to an overcrowded curricula, lack of textbooks addressing safety and health, and a lack of safety and health trained engineering instructors (Kauffman, 1987). The addition of a required course in safety and health, however, is only one method or alternative to educating engineering students. Other possible approaches include introducing key safety and health topics into existing courses, providing technical elective courses, and mini-lectures (Talty, 1986). Through curriculum development projects, like SHAPE, introduced at Purdue University, Ohio State University, Georgia Institute of Technology, and Tufts University, safety and health are being integrated into other engineering curricula (Kauffman, 1987). Students involved in the NIOSH curriculum development project have stated that safety and health instruction was necessary especially for students going to work in the industrial world (Talty,1987). One proponent of safety and health cites: "It is neither necessary nor desirable to make all chemical engineering students experts in safety and health. However, increasing student awareness, interest, and knowledge of health and safety protection is like preventative medicine, and it is much less grievous and expensive than remedial action" (Flieschman, 1988). Besides the NIOSH curriculum development project, other individuals have sought to integrate safety and health into their engineering schools' curricula. Since 1977, Delft University of Technology, Delft, the Netherlands, has implemented an educational program incorporating health, safety, environmental and social aspects of chemical engineering in the educational and research activities. A required first year course, Chemistry and Society/Industrial Orientation, studies how industries and government react to environmental and safety problems. A third year required course, Chemical Risk Management, covers safety and health from a risk in health, safety and environmental perspective. A Safety Report is a required activity for all fourth year students and graduate students. The program has been followed by more than two thousand students over a fifteen-year period and requires extensive cooperation with industry (Lemkowitz, 1992). Industries and environmental groups participating in the program include Shell, ICI, Dow, DuPont, Cyananid, Unilever, Hoechst, Kuwait Petroleum, AKZO, Green Peace, Friends of the Earth, and other local environmental groups. Over the years, the program has fostered a tremendous amount of success and respect and has benefited government, industry and environmental groups (Lemkowitz, 1992).

Mini-lectures

Another approach, using mini-lectures, was taken by the Chemical and Nuclear Engineering Department, University of New Mexico, Albuquerque, New Mexico. The mini-lectures generally take place in the Senior Design class. They cover 13 topics and are a ten to fifteen minute discussion of a single topic per lecture. The lecture and discussions are designed around problems or topics that the students currently are studying. Homework and class exercises have been added in order for the students to obtain a minimum awareness and understanding of common analytical tools and data sources related to safety and health (Kauffman, 1987).

Farwell, et. al. Study

In a study conducted in 1992, 157 undergraduate engineering professors were asked why it was necessary to integrate safety and health into instructional curriculum. Seventy nine percent of the respondents believed it necessary to address Occupational Safety and Health (Farwell, et al., 1995). The top five factors why professors (n=89) include OS&H were: personal interest (93.3%), ethical consideration (82.0%), department encouragement (59.6%), concerns for personal liability (51.7%) and ABET requirements (50.6%). The factors contributing to professors' (n=66) reason for not addressing OS&H in their courses were: No room in the curriculum (68.2%), Not relevant to the course I teach (62.1%), and Few materials currently available (42.4%). The sources for information regarding safety and health in the different approaches professors (n=86) used in their courses were: develop own material (40.7%), colleagues (41.9%), rely on scientific journals (40.7%), professional society (34.1), engineering conferences or workshops (31.4%), review of other university curricula/courses (22.4%), alumni (12.8%) and APHA (American Public Health Association) conferences or workshops (2.3%). The recommendations for greater OS&H integration into the engineering curriculum were: 1) Engineering instructors should be given or provided with opportunities to learn about the importance of safety and health engineering; 2) NIOSH and other professional associations should facilitate the development of safety and health course materials; 3) ABET needs to be more specific in defining it's accreditation criteria in safety and health and deny accreditation to schools who fail to meet these requirements; and 4) Networks of engineering faculty members to share OS&H related materials and information (Farwell, 1995).

Experience Versus Instructing

One great problem that is facing the engineering community at this time is the division between engineers who are "doing" engineering and those who are "instructing" engineering" (Henshaw, 1991). In the three integration examples, Delft University seems to be most in line with what industry is looking for in their engineers as well as in the need for integration of safety and health. Kauffman points out that most chemical engineering faculty in the United States have very little knowledge of health and safety matters. Even among the minority that have significant industrial experience in plant operations or design work, the level of knowledge of safety and health is low (Kauffman, 1987). Thirty years ago academians knew what was needed in their programs because of their knowledge of the practice of engineering. Henshaw states, "Today, most lecturing academians have not practiced the profession" (Henshaw, 1991). In a survey of advertisements for professional engineering jobs, companies' advertisements state in various ways that employers are looking for engineers who have "actually done it," not those who have simply read about it (Henshaw, 1991). Vasilca (1994) gives his personal view on the training of engineers from a perspective of a senior executive position of a United States manufacturing corporation. He stresses the importance of cross-disciplinary education at the undergraduate level. He supports a short undergraduate education program followed by life-long training and upgrading activities. He is a proponent of a shorter classroom experience and longer hands on, field experience (Vasilca, 1994).

The outcomes for engineering programs, from an industry standpoint, appear to be less than optimal. Injuries and illness rates in manufacturing, construction, and transportation remain to be the highest amongst all business groups. In the State of Oregon, manufacturing had 12.3, construction had 11.6, and transportation had 9.9 incidence rates per one hundred employees in 1994 (Oregon Occupational Injury and Illness Survey, 1994). Engineering controls and practices can have a profound influence in reducing these rates.

Accreditation and Communication

Farwell, et. al.'s (1995) recommendations that ABET define more specifically its accreditation requirements for safety and health and that it deny accreditation for those who do not meet those criteria would help to standardize outcomes. Professional engineering societies need to communicate specific health and safety criteria to ABET in order that these criteria satisfy industries needs for securing a safer and healthier work environment.

METHODS

The questionnaire was developed based on the need to evaluate the importance of integrating Environmental Safety and Health into the undergraduate engineering curricula. The questionnaire targeted companies who recruited graduating Bachelor of Science Engineering students at OSU for employment during the academic years 1993/1994 and 1994/1995. This survey instrument was reviewed by Pamela Bodenroeder, OSU Survey Research Center. A pilot mailing was sent to eleven individuals representing ten companies. Three of these individuals were engineers and members of the Eugene Chapter of the American Society of Safety Engineers. Four were plant engineers who are members of the Columbia River Chapter of the American Institute of Plant Engineers. And four were Industrial Relations/Human Resources managers. Revisions to the questionnaire were built upon recommendations made by those responding to the pilot survey. A copy of the survey appears in the Appendix.

The target population consisted of all recruiters that sought graduating engineering students for the academic years 1993/1994 and 1994/1995. A roster of recruiters and the companies they represented was generated from records kept in the OSU Career Placement Office. The total population consisted of 110 recruiters from that two-year period.

The survey was administered by following the mailing survey principles outlined in Priscilla Salant and Don A. Dillman's book *'How to Conduct Your Own*

Survey.' Each recruiter was sent a personalized, advance-notice letter informing him/her that a survey was going to be mailed to him/her. One week later, a personalized cover letter and the survey was sent to each of the 110 potential participants. The letter provided more detail concerning the general purpose of the survey: "The goal of the survey is to learn how influential safety and health education/instruction are in determining the employability of a potential engineering graduate." The letter also stated: "My goal is to learn how influential this background is in the employability of engineering graduates and thereby incorporate this instruction at an appropriate level into students' academic development for employment." A stamped return envelope was included with each survey mailed.

Eight days after the survey was mailed, a follow-up postcard was mailed thanking those who had responded and requesting a response from those who had not yet had the opportunity to respond.

The final mailing, three weeks after the initial mailing, was sent to the targeted population who had not yet responded. This mailing included a new personalized cover letter with a replacement questionnaire and stamped return envelope.

Four surveys were returned unanswered for the following reasons: two because the recruiter was no longer with the company that they previously had represented while recruiting at OSU, and two had undeliverable addresses. A total of 72 surveys were returned for an overall response rate of 65.5%. One returned survey was eliminated from the data analysis because it was filled out improperly.

The data were analyzed using SPSS for Windows, Release 6.1.

RESULTS

Importance of Qualifications

Question 2 of the questionnaire asked respondents to circle how important a qualification may or may not be when selecting Bachelor of Science Engineering students for employment. Table 2 lists these qualifications and how recruiters ranked their importance. All 71 survey respondents answered this question. Communication Skills (n=58 [81.7%]), Problem Solving Skills(n=53 [74.6%]), and Analytical Skills (n=48 [67.6%]) were considered 'Very Important' qualifications for recruiters seeking potential engineering employees. Leadership Skills (n=37 [52.1%]) and Experience (n=35 [49.3%]) were the next cluster of qualifications that were identified as 'Very Important'. Three (n=3 [4.3%]) respondents considered Environmental Safety and Heath (ES&H) Instruction/Education as a 'Very Important' qualification when considering an engineering graduate for employment.

Recruiters identified Grades (n=46 [64.8%]), Personal Appearance (n=46 [64.8%]), and the School Attended (n=39 [54.9%]) as 'Somewhat Important' qualifications for potential Engineering employees. Twenty-four percent (n=17) of the recruiters responded that ES&H was 'Somewhat Important.'

Letters of Recommendation (n=36 [51.4%]) and ES&H (n=32 [45.1%]) were identified as the two categories recruiters found 'Not Too Important' as qualifications for employment. The other significant qualification in this category

TABLE 2

LIST OF QUALIFICATIONS BY IMPORTANCE WHEN CONSIDERING A BS ENGINEERING STUDENT FOR EMPLOYMENT

LIST OF QUALIFICATIONS	HOW IMPORTANT				
	VERY n (%)	SOMEWHAT n (%)	NOT TOO n (%)	NOT AT ALL n (%)	TOTAL n (%)
EXPERIENCE	35 (49.3%)	26 (36.6%)	9 (12.7%)	1 (1.4%)	71 (100%)
GRADES	18 (25.4%)	46 (64.8%)	6 (8.5%)	0	70 (100%)
SCHOOL ATTENDED	8 (11.3%)	39 (54.9%)	22 (31%)	2 (2.8%)	71 (100%)
LEADERSHIP SKILLS	37 (52.1%)	30 (42.3%)	4 (5.6%)	0	71 (100%)
COMMUNICATION SKILLS	58 (81.7%)	13 (18.3%)	0	0	71 (100%)
PROBLEM SOLVING SKILLS	53 (74.6%)	15 (21.1%)	0	1 (1.4%)	69 (100%)
ANALYTICAL SKILLS	48 (67.6%)	21 (29.6%)	2 (2.8%)	0	71 (100%)
ENVIRONMENTAL SAFETY AND HEALTH INSTRUCTION/EDUCATION	3 (4.2%)	17 (23.9%)	32 (45.1%)	18 (25.4%)	70 (100%)
LETTERS OF RECOMMENDATION	3 (4.2%)	25 (35.2%)	36 (51.4%)	6 (8.5%)	70 (100%)
PERSONAL APPEARANCE	10 (14.1%)	46 (64.8%)	14 (19.7%)	0	70 (100%)

was the School Attended for potential candidates at 22 (31%). In the 'Not At All Important' category for qualifications desired by recruiters, ES&H Instruction/Education received the highest marks at 18 (25.4%). Eighteen of seventy-one respondents (n=18 [25.4%]) indicated that they believed ES&H Instruction/Education was 'Not At All Important' as a qualification for employment when considering a candidate for employment.

Kind of Engineer Most Employed and Kind of Engineer Second Most Employed

Question 3 requested respondents to identify the two kinds of engineers employed most frequently by their firm. Table 3 lists the responses for 'Kind of Engineer Most' and the 'Kind Second Most Employed' by their respective company. Mechanical, Chemical, Civil, and Electrical Engineers had the highest representation in both categories. Based on the responses to Question 3, recruiters were then asked, in Question 4, if they were to hire a newly graduated engineer in these fields of expertise, 'How important would ES&H be when considering a candidate for employment ?'. Table 4 presents the responses for the 'Importance of ES&H When Considering a BS Engineering Graduate' for those most and second most occupied engineering positions within their companies. Question 4 differs from Question 2 (qualifications of a candidate) in that Question 4 asks recruiters how important ES&H are when hiring engineers into a position occupied by the two kinds of engineers most employed. 25% (n=18) indicated that ES&H was 'Very' or 'Somewhat Important', while 75%

TABLE 3

KINDS OF ENGINEERS MOST EMPLOYED BY THE RECRUITER'S RESPECTIVE COMPANY

KIND OF ENGINEER	FREQUENCY OF MOST EMPLOYED n (%)	FREQUENCY OF SECOND MOST EMPLOYED n (%)
Mechanical	18 (25.7%)	21 (29.6%)
Chemical	15 (21.4%)	8 (11.3%)
Civil	13 (18.6%)	5 (7.0%)
Electrical	8 (11.4%)	7 (9.9%)
Construction	5 (7.1%)	2 (3.4%)
Computer Science	5 (7.1%)	5 (7.0%)
Industrial	3 (4.3%)	4 (5.6%)
Electronic	3 (4.3%)	1 (1.4%)
Other	0 (0%)	6 (8.5%)
Missing	1 (1.4%)	12 (16.9%)
TOTAL	71 (100%)	71 (100%)

TABLE 4

IMPORTANCE OF ES&H WHEN CONSIDERING A BS ENGINEERING GRADUATE, ENGINEERS MOST EMPLOYED AND SECOND MOST EMPLOYED

	VERY IMPORTANT n (%)	SOMEWHAT IMPORTANT n (%)	NOT TOO IMPORTANT n (%)	NOT AT ALL n (%)	TOTAL n (%)
KIND OF ENGINEER MOST EMPLOYED	3 (4.2%)	15 (21.1%)	26 (36.6%)	27 (38.0%)	71 (100%)
KIND OF ENGINEER SECOND MOST EMPLOYED	2 (2.8%)	15 (21.1%)	25 (35.2%)	18 (25.4%)	60 (100%)

(n=53) believed that it was 'Not Too' or 'Not At All Important'. The Second Kind of Engineer Most Employed had eleven missing responses. These were responses from recruiters whose companies employ only one kind of engineer. The responses tabulated were very consistent with the 'Kind of Engineers Most Employed' category. Twenty-four percent (n=17) felt ES&H was 'Very or Somewhat Important'. Meanwhile, 61% (n=43) indicated that ES&H was 'Not Too' or 'Not At All Important' when considering a candidate filling this kind of engineering position in their company.

Level of Knowledge/Education

Those that answered 'Not Too' or 'Not At All Important' to Question 4 were asked to proceed to Question 5. Those that responded 'Very or Somewhat Important' to Question 4 were then asked to respond to Questions 4a and 4b. Question 4a asks the recruiter to indicate the level of ES&H Knowledge/Education that would be acceptable for an engineering graduate being hired into the position indicated in Question 3 (Kind of Engineer Most and the Kind of Engineer Second Most Employed). Table 5 contains the responses to Question 4a. The most desirable source of knowledge/education was integration of ES&H into the engineering curriculum. Eight of eighteen (44.4%) and 8 of seventeen (47.1%) preferred this type or level of training for the Kind of Engineer Most Frequently Employed and Second Kind Most Frequently Employed, respectively. The other levels of ES&H Knowledge/Education were

TABLE 5

LEVEL OF KNOWLEDGE/EDUCATION OF ES&H FOR BS ENGINEERING STUDENTS

	MINOR IN ES&H n (%)	SMALL NUMBER OF CLASSES (3<) n (%)	INTEGRATION OF EH&S INTO CURRICULUM n (%)	ATTEND ES&H CONFERENC ES/SEMINARS n (%)	ON THE JOB TRAINING n (%)	TOTAL n (%)
KIND OF ENGINEER MOST EMPLOYED	1 (5.6%)	4 (22.2%)	8 (44.4%)	3 (16.7%)	2 (11.1%)	18 (100%)
KIND OF ENGINEER SECOND MOST EMPLOYED	1 (5.9%)	5 (29.4%)	8 (47.1%)	2 (11.7%)	1 (5.9%)	17 (100%)

TABLE 6

GRADUATING BS ENGINEERING STUDENTS ADVANTAGE OF EMPLOYMENT WITH ES&H KNOWLEDGE/EDUCATION
(these are responses of those answering 'Somewhat' or 'Very Important' in Question 4)

	MORE LIKELY n (%)	LESS LIKELY n (%)	NO DIFFERENCE n (%)	TOTAL n (%)
KIND OF ENGINEER MOST EMPLOYED	10 (55.6%)	0	8 (44.4%)	18 (100%)
KIND OF ENGINEER SECOND MOST EMPLOYED	9 (52.9%)	0	8 (47.1%)	17 (100%)

from a 'Small Number (3<) of Classes' (22.9% and 29.4%) and from attending 'ES&H Conferences and Seminars' (16.7% and 11.8%).

Respondents to Question 4 indicating that ES&H were 'Somewhat Important' or 'Very Important', were asked in Question 4b, 'Are graduating BS engineering student with ES&H knowledge/education more or less likely to gain employment in your firm compared to graduates who do not have ES&H knowledge/education?' Table 6 lists the responses to this question. Recruiters indicated that over half (55.6% and 52.9%) of those being considered for employment had an advantage over other candidates that did not have ES&H Knowledge/Education. The remaining respondents (44.4% and 47.1%) indicated that having ES&H knowledge/education, made no difference. None of those surveyed indicated that those candidates with ES&H knowledge/education would be less likely to gain employment compared to those that did not have ES&H Knowledge/Education.

Kind of Training After Hire

In Question 5, recruiters were asked how likely their firm would be in sending a newly hired engineer to ES&H training (Table 7). Twenty-seven respondents (38%) indicated that engineers in the 'Kind Most Employed' category were 'Likely' or 'Somewhat Likely' to attend training. Twenty-four (40%) of those in the 'Kind of Engineer Second Most Employed' were 'Likely' or

TABLE 7

LIKELIHOOD OF SENDING A NEWLY HIRED ENGINEERING GRADUATE TO ES&H TRAINING (Question 5)

	VERY LIKELY n (%)	SOMEWHAT LIKELY n (%)	NOT LIKELY n (%)	NOT SURE n (%)	TOTAL n (%)
KIND OF ENGINEER MOST EMPLOYED	10 (14.3%)	17 (24.3%)	37 (52.8%)	6 (8.6%)	70 (100%)
KIND OF ENGINEER SECOND MOST EMPLOYED	10 (16.1%)	14 (22.6%)	32 (51.6%)	6 (9.7%)	60 (100%)

TABLE 8

KIND OF TRAINING AN ENGINEER WILL ATTEND AFTER BEING HIRED (responses based on Question 5 - the likelihood of sending a newly hired BS Engineering graduate to ES&H training)

	ATTEND ES&H CONFERENCES/SEMINARS n (%)	ON THE JOB TRAINING n (%)	TOTAL n (%)
KIND OF ENGINEER MOST EMPLOYED	7 (24.1%)	22 (75.9%)	29 (100%)
KIND OF ENGINEER SECOND MOST EMPLOYED	6 (23.1%)	20 (76.9%)	26 (100%)

'Somewhat Likely' to attend training. Thirty-seven (53%) in the 'Kind Most Employed' and thirty-two (53%) 'Kind Second Most Employed' categories indicated that the newly hired engineer would 'Not Likely' attend ES&H Training. If a recruiter responded 'Likely' or 'Somewhat Likely' to Question 5, they were requested to continue on to Question 5a. Those that responded 'Not Likely' or 'Not Sure', were requested to continue on to Question 6.

Question 5a asked the recruiter what type of ES&H training a newly hired engineer would most likely attend after they were hired for employment. Table 8 provides the responses to this question. Three-fourths of the respondents indicated that candidates would attend ES&H training on the job. The remaining one-fourth indicated that the engineer(s) would attend ES&H conference(s)/seminar(s). There were no responses in the 'Attend a University Course(s) in ES&H' or 'Other' categories.

Business Information Communicated by the Recruiters

Questions 6 through 10 asks recruiters to list information regarding their firms business involvement, regions of the United States where they have business facilities, whether or not they have international facilities, and the size of their company at their business site.

The recruiter's description of their firm's business involvement is represented by the following responses from Question 6. The largest number of responses came from recruiters representing the Industrial/Manufacturing sector

TABLE 9

REGIONS OF THE UNITED STATES IN WHICH RECRUITERS HAVE BUSINESS FACILITIES

REGION	FREQUENCY	PERCENT
REGION I	22	31.0%
REGION I & II	3	4.2%
REGION I & III	5	7.0%
REGION I & IV	3	4.2%
REGION I, II, III	3	4.2%
REGION I, II, IV	3	4.2%
REGION I, II, III, IV	32	45.2%
TOTAL	71	100%

TABLE 10

INTERNATIONAL BUSINESS FACILITIES

RESPONSE	NUMBER	PERCENTAGE
YES	49	69.0%
NO	22	31.0%
TOTAL	71	100%

TABLE 11

APPROXIMATE NUMBER OF EMPLOYEES IN THE RECRUITER'S FIRM AT THEIR BUSINESS LOCATION

COMPANY SIZE (NUMBER OF EMPLOYEES)	FREQUENCY	PERCENT
1 - 99	16	22.5%
100 - 499	25	35.2%
500 - 1000	11	15.5%
1001- 60,000	19	26.8%
TOTAL	71	100%

of business with 28 (39.4%). Those representing the Construction domain responded 14 (19.7%) times. Electronics, Consulting, Research and Development, and Agriculture responded 6 (8.5%), 5 (7.0%), 4 (5.6%), and 3 (4.3%) times respectively. Other responses came from recruiters involved in Transportation, Petroleum, Hazardous Waste Treatment, Aerospace, Sales, Telecommunications, Software Development, and Business Insurance, totaling 11 (15.5%).

Table 9 shows the regions of the United States where the recruiters have business facilities. Twenty-two (31%) responded that they had facilities in Region I, which comprises the western states. There were no other single regions represented. The largest representation came from recruiters that had business facilities in all four regions (n=32 [45.2%]). The remaining (n=17 [23.8%]) responses represented businesses in two or three regions, all including Region I.

Sixty-nine percent of businesses represented have international facilities, while twenty-two percent did not (Table 10). Table 11 illustrates the size of the company that the recruiter represents. 22.5% were recruiting for companies with fewer than 100 employees. Recruiters coming from the 100 to fewer than 500 employee sized companies, represented 35.2% of the total. 500 to 1000 employee category, 15.5% of respondents were employed by companies of this size. There was a 26.8% representation in the greater than 1000 to 60,000 employee column.

DISCUSSION

Increase Business Productivity, Manufacturability, and Profitability

Literature cited earlier indicated Environmental Safety and Health (ES&H) should be an integral part of an engineer's educational preparation for practice. Yet, survey responses from recruiters seeking engineers for employment from Oregon State University indicated that ES&H are 'Not Too' or 'Not At All' Important as a qualification for employment. The two largest business types represented, Industrial/Manufacturing and Construction, responded most often that ES&H were not very important as a qualification in making a hiring decision. However, these two business types also have the highest injury/illness rates in the State of Oregon (Oregon Occupational Injury and Illness Survey, 1994). If these two business types were to incorporate ES&H a high priority as a qualification for employment, they would see steady and dramatic decreases in the injury illness rates. Talty (1987) stated that '... the talent and ability of managers and engineers should be applied to the solutions (of injuries and illnesses) through education programs concerning safety and health.' Businesses and industry have a great opportunity to reduce injuries and illnesses in the workplace and eradicate catastrophic events like Bhopal, Three-mile Island, and large petro-chemical spills through engineering design and practices. An added benefit resulting from ES&H practices would be increased productivity, manufactuablity, and profitability (ABET Criteria 2000). Businesses stand to be recognized as good corporate citizens, and reliable product developers and suppliers.

ES&H Tools

The Accrediting Board for Engineering Technology (ABET) has not defined specific outcomes in ES&H criteria for engineering school accreditation. ABET, in principle, is directing schools of engineering in the right direction by having the ES&H criteria. However, the lack of sufficient 'tools' to place in engineering instructor's hands are sparse. The outcomes of the criteria need to be identified to the specific engineering types. Engineering Societies, Safety and Health Societies, and Management Societies need to assist in the 'tool' identification and development. These 'tools' may include: Specific Curriculum Topics (e.g. NIOSH - Project SHAPE); safety professionals team instructing with Engineering Instructors; tool development from partnerships formed between communities, industry, universities, and activist groups (Delft Model); and instructional tools developed from materials shared between engineering instructors via networks set up to dispense information (Farwell, et. al. Model). These 'tools' would equip graduating B.S. engineering students with the ability to identify and control hazards resulting in injuries and illnesses in the earliest phases of design and development.

Revisiting The Survey

If the survey reported in this thesis were to be performed again, I would recommend several changes. First,Question 1 would be eliminated. There is little value added to the survey results from this question. In the question's place, a definition of ES&H would appear in order to provide all respondents with a reference point to follow as they worked through the survey.

Results may differ if one or more of the following guidelines were followed: If one business type were to be surveyed, such as manufacturing; If the survey was given to the direct supervisor of the recruiter or second interviewer; If the survey was performed between recruiters seeking engineers from one of the NIOSH Curriculum Development Schools (e.g. Georgia Institute of Technology) and those recruiting engineers from OSU; a sample population compiled with a minimum of 500 participants to be surveyed; Survey those industries or business types with the highest injury and illness rates who are seeking graduating engineering students.

Secondly, I would survey those business types with the highest injury illness rates who are seeking graduating B.S. engineering students. Potential benefits might include:

- Increased concentration of ES&H in the engineering curriculum for engineers of these business types.
- Creating an awareness in these business types that engineering

- controls might be applied to reduce injuries and illnesses.
- Assist ABET in identifying specific outcomes for the required safety and health criteria in the accreditation process for engineering schools.

CONCLUSIONS AND RECOMMENDATIONS

This study evaluated the employment advantages that a graduating Bachelor of Science Engineering student might gain by having ES&H instruction/education at Oregon State University, Corvallis, Oregon. From the results, the following conclusions were determined:

1) Environmental Safety and Health (ES&H) knowledge does not give a BS in Engineering graduate being recruited at OSU a consistent advantage for employment compared with engineering graduates who do not have ES&H instruction/education.

2) Companies represented by recruiters seeking graduating engineers from OSU find ES&H knowledge not too or not at all important as a qualification for employment.

3) Those recruiters that found ES&H an important qualification for employment of graduating engineers from OSU, identified the greatest desirable source for that knowledge to be integration into the engineering curriculum.

4) After an engineer graduating from OSU is hired for employment by a company, he/she is most likely to receive ES&H training on the job.

Based on these conclusions, the following recommendations are suggested:

1. Based upon the literature reviewed and responses from businesses involved in manufacturing and construction, communication between the School of Engineering and these two groups needs to improve to determine how

engineers at Oregon State University should best be prepared for employment and responsibilities for the safety and health of workers.

2. Based upon ABET'S criteria for accreditation, the School of Engineering at OSU needs to communicate with business groups and engineering societies, what level and how detailed safety and health instruction/education should be to adequately train them for employment.

3. The safety community needs to communicate with management, engineers, engineering societies, and the engineering school at OSU, the great need for engineering controls and designs in the pursuit of injury and illness reduction.

Several sources for potential error warrant discussion. Several comments received on the questionnaire indicated respondents were not clear as to how ES&H were being defined. The survey or communication letters offered no definitions of ES&H. Responses came from respondents own definition and understanding. The population that was surveyed varied in the positions they maintained. Therefore, certain biases in employee types may have influenced the respondent's answers in the survey. There were four categories of recruiters. There were professional recruiters of varied backgrounds, plant engineers, human resources directors, and business owners.

Another source of error may have come in assembling the population for the survey. The records kept in the OSU Placement Office could possibly have not been complete. Records kept on a company seeking sales representatives, marketing directors and engineers may have been filed in the Business School records. The way words were used in the questions may have resulted in measurement error. For example, Question 2 states: 'Below is a list of qualifications that may or may not be used in selecting Bachelor of Science engineering students for employment. Please indicate how important each is to you when considering a candidate for employment.' The choices for response were 'Very', 'Somewhat', 'Not Too', and 'Not At All Important' and were not clearly defined as to their specific meaning. These phrases may not have been understood in the same way by all respondents.

Another source of measurement error may have occurred in the structure of the questionnaire. For an example, respondents were requested to write in answers to Question 3 ('Please write in the spaces provided the two (2) kinds of engineers most employed by your firm'). Based on these responses, they were asked to answer the questions. The questions that followed asked respondents to answer based upon Question 3's responses. In Question 4, ('When considering newly graduated BS Engineering students from the two fields your firm employs, how important is it to your firm that they have Environmental Safety and Health (EH&S) knowledge/education when making a decision for employment?'), those that responded 'Not At All Important' or 'Not Too Important' were directed to go to Question 5. Those that responded "Somewhat Important' or 'Very Important' were then directed to Question 4a. Because Question 4b was on the third page of the questionnaire, the line direction did not continue. This question structure may have confused respondents from answering correctly or following the questionnaire.

The integration of safety and health into the curriculum is required by ABET. ES&H are not too important for potential employers of graduating BS Engineering students at Oregon State University. However, literature suggests ES&H needs to be an integral part of an engineer's educational experience. The literature also suggests that integration of safety and health ideals/principles into the existing classes is the most effective way. NIOSH has established instructional topics and curriculum guidelines for engineering schools for integration purposes. Companies that recruit graduating BS Engineering students from Oregon State University need to come to the realization that engineers can make major contributions to preventing occupational injuries, illnesses and deaths. By being effective in this arena, the sustainability, manufactureability and profitability of businesses stand to increase.

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Appendix

Appendix - Survey

SURVEY CONCERNING ENGINEERING COLLEGE GRADUATES

1. In the following table, please indicate how many of each kind of engineer your firm currently employs. For each kind of engineer your firm does not employ please write Ø.

	How Many
A. Mechanical	______
B. Electrical	______
C. Chemical	______
D. Environmental	______
E. Civil	______
F. Industrial	______
G. Computer Science.	______
H. Nuclear	______
I. Electronics	______
J. Other(s). Please specify	
a.______________	______
b.______________	______

2. Below is a list of qualifications that may or may not be used in selecting Bachelor of Science engineering students for employment. Please indicate how important each is to you when considering a candidate for employment. (*Circle one number for each*)

	HOW IMPORTANT?			
	VERY	SOME-WHAT	NOT TOO	NOT AT ALL
a. Experience.	1	2	3	4
b. Grades	1	2	3	4
c. School Attended	1	2	3	4
d. Leadership Skills	1	2	3	4
e. Communication Skills	1	2	3	4
f. Problem Solving Skills	1	2	3	4
g. Analytical Skills	1	2	3	4
h. Environmental Safety and Health instruction/education . .	1	2	3	4
i. Letters of Recommendation. . . .	1	2	3	4
j. Personal Appearance	1	2	3	4
k. Others (Please Specify)				
a . ______________	1	2	3	4
b. ______________	1	2	3	4

Please answer questions 3 through 5 by referring to the two (2) kinds of engineers employed most by your firm. If you employ only kind of engineer, please answer the questions regarding the one kind of engineer most employed.

3. Please write in the spaces provided the two (2) kinds of engineers most employed by your firm.

a.________________________________ KIND OF ENGINEER MOST EMPLOYED

b.________________________________ KIND OF ENGINEER SECOND MOST EMPLOYED

4. When considering newly graduated B.S. engineering students from the two fields your firm employs most, how important is it to your firm that they have Environmental Safety and Health (EH&S) knowledge/education when making a decision for employment?

	(a) Kind of Engineer Most Employed (*__circle one__*)	(b) Kind of Engineer Second Most Employed (*__circle one__*)
NOT AT ALL IMPORTANT (GO TO Q 5). .	1	1
NOT TOO IMPORTANT (GO TO Q 5).	2	2
SOMEWHAT IMPORTANT	3	3
VERY IMPORTANT	4	4

4a. Which one of the following would be an acceptable level of Environmental Safety and Health (ES&H) knowledge/education?

	(a) Kind of Engineer Most Employed (*__circle one__*)	(b) Kind of Engineer Second Most Employed (*__circle one__*)
A MINOR IN ES&H	1	1
A SMALL NUMBER OF ES&H COURSES (3<)	2	2
INTEGRATION OF ES&H CONCEPTS THROUGHOUT ENGINEERING CURRICULUM	3	3
ATTENDED ES&H CONFERENCES AND/OR SEMINARS.	4	4
ON THE JOB TRAINING	5	5

4b. Are graduating B.S. engineering students with ES&H knowledge/education more likely or less likely to gain employment in your firm compared to graduates who do not have ES&H knowledge/education; or doesn't it make a difference?

	(a) Kind of Engineer Most Employed (*circle one*)	(b) Kind of Engineer Second Most Employed (*circle one*)
MORE LIKELY	1	1
LESS LIKELY	2	2
NO DIFFERENCE	3	3

5. Once employed, how likely is it your firm will send a newly hired engineering graduate to Environmental Safety and Health (ES&H) training?

	(a) Kind of Engineer Most Employed (*circle one*)	(b) Kind of Engineer Second Most Employed (*circle one*)
NOT SURE	1	1
NOT LIKELY	2	2
SOMEWHAT LIKELY	3	3
VERY LIKELY	4	4

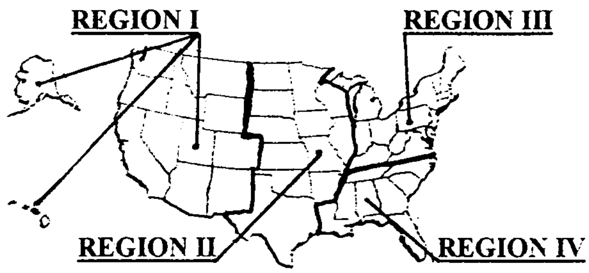
5a. Please indicate which one of the following which best describes the kind of ES&H training the newly hired engineer might attend?

	(a) Kind of Engineer Most Employed (*circle one*)	(b) Kind of Engineer Second Most Employed (*circle one*)
A UNIVERSITY COURSE(S) IN ENVIRONMENTAL SAFETY AND HEALTH (ES&H)	1	1
ATTEND AN ES&H CONFERENCE(S) OR SEMINAR(S)	2	2
ON SITE ES&H TRAINING	3	3
OTHER ____________________	4	4

6. Which **one** of the following best describes your firm's business involvement? (***please circle one number***)
   01 INDUSTRIAL/MANUFACTURING
   02 CONSTRUCTION
   03 MINING
   04 RESEARCH & DEVELOPMENT
   05 REMEDIATION
   06 AGRICULTURE/FORESTRY
   07 TRANSPORTATION
   08 UTILITIES
   09 CONSULTING
   10 ELECTRONICS
   11 OTHER(S) (PLEASE SPECIFY)____________________________________

7. In which region(s) of the United States do you have business facilities? (***please circle one number for each* Region**)

	YES	NO
a. Region I	1	2
b. Region II	1	2
c. Region III	1	2
d. Region IV	1	2



9. Does your firm have international business facilities?

   1 YES
   2 NO

10. Please indicate the approximate number of employees (including engineers) in your firm at your business site.

    _____________TOTAL EMPLOYEES

11. Please indicate the approximate number of colleges/universities you have visited in the past two years for the purpose of recruiting Bachelor of Science Engineering students.

    ______________ NUMBER OF COLLEGES/UNIVERSITIES YOU'VE VISITED IN THE PAST TWO YEARS TO RECRUIT ENGINEERING GRADUATES

12. Is there anything else you would like to comment about Engineering graduates and Environmental Safety and Health (ES&H) education/instruction as it pertains to employment?

THANK YOU FOR YOUR HELP AND COOPERATION